DELAWARE ELECTRIC COOPERATIVE

"TECHNICAL REQUIREMENTS FOR PARALLEL OPERATION OF MEMBER-OWNED GENERATION"

EFFECTIVE APRIL 1, 2000

TECHNICAL REQUIREMENTS FOR PARALLEL OPERATION OF MEMBER-OWNED GENERATION

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Technical Requirements For Parallel Operation of Member-Owned Generation

A – Renewable Energy Generation 25 KW or Less

1. Applicability

   1.1 Applicable to residential, general and small commercial Members where a part or all of the electrical requirements of the Member can be supplied from a renewable energy electric power production source (solar, wind, hydro, biomass or geothermal energy generation) where: 1) such source is connected for parallel operation with the service of the Cooperative, 2) where such source is located on the Member's premises and 3) where the Member owns or operates the renewable energy generator.

   1.2 When applications for such service are approved by the Cooperative it will then be obligated to provide back-up service in the event the renewable energy generation facility fails. To limit the Cooperatives liability in this regard it may refuse to approve such service, at its sole discretion, when the aggregate combined load of this classification of service reaches 4 MVA, or for a single qualified renewable energy generation when that type reaches an aggregate combined capacity (load) of 2 MVA.

2. Metering

   2.1 Eligible Members installing renewable energy generation facility not exceeding 25 kW shall be based on Net Energy Metering. The Member must notify the Cooperative in writing at least 30 days prior to activating a renewable energy generating facility.

   2.2 The Cooperative will install, own and maintain all metering equipment needed to measure the energy supplied to the Member. The Cooperative will provide a meter to measure the flow of electricity in both directions, of the same capacity as that provided to a non-eligible Member under the same rate schedule as would have applied if the Member was not eligible for Net Energy Metering. The meter supplied by the Cooperative under this tariff shall be accurate to within ±2% when registering in reverse, that is during those times when the Member-generator's instantaneous generation is greater than the Member's consumption. A Member receiving service under this Option is billed under the identical energy (forward and reverse flow) and Member charges, rate structure, monthly charges and minimum charges that would be assigned if the Member were not an eligible Member-generator. In order to reduce metering and administrative costs, the Cooperative reserves the right to place the Member-generator on a flat rate service with a flat rate meter if such service and metering

is ordinarily available to a Member if that Member was not an eligible net metered generator.

2.3 If the energy supplied by the Cooperative exceeds the electricity generated by the Member during the applicable billing period, the Member shall be billed for the net energy supplied by the Cooperative during the billing period. If the energy generated by the Member exceeds the energy supplied by the Cooperative during the billing period, the Member shall be required to pay only the Member charges for that billing month. Any excess kilowatt hours of Member generated electricity in a billing period shall be carried forward into the next billing period as a kilowatt hour credit to be used solely by the Member to offset energy supplied to the Member by the Cooperative. The Cooperative may use an estimated meter reading and/or billing to accomplish the kilowatt hour credit carry forward.

2.4 At the beginning of each calendar year (January 1), any remaining unused kilowatt-hour credit accumulated by the Member during the previous year may be sold by the Member to any Electric Supplier that agrees to purchase such credit. In the absence of any such purchase, the credit shall be assigned to the Electric Supplier that supplied electric energy to the Member at the end of the previous year.

3. System Modifications

3.1 If it is necessary for the Cooperative to modify portions of its existing system to provide larger capacity facilities or metering to accommodate the purchase of electricity from the Member, the Member will be responsible for the costs of said upgrades. Should system modification be necessary, the Cooperative, at the Member's expense, shall perform all work on the Cooperative's side of the meter.

4. Safety, Liability and Responsibilities

4.1 Any renewable energy generating facility used by a Member pursuant to this Option shall meet all applicable safety and performance standards established by the National Electric Code, The Institute of Electrical and Electronics Engineers and Underwriters Laboratories.

4.2 The Member must obtain, at his or her expense, all necessary inspections and approvals required by codes prior to connecting the facility to the Cooperative's system. The Member will supply the Cooperative with certification that the facility has received all necessary code approvals and that it meets, or exceeds, all applicable safety and performance standards.

4.3 Parallel operation with the Cooperative's system must cease immediately and automatically during system outages and other emergency or abnormal conditions as specified by applicable codes and standards. The Member's generator must cease parallel operation upon notification by the Cooperative if such operation is deemed unsafe or interferes with the supply of service to others, or interferes with system operation or maintenance. The Cooperative accepts no responsibility for damage or injury to any person or property caused by the failure of the Member to operate in compliance with the Cooperative's or any other requirements.

4.4 Failure of the Member to comply with any of these requirements shall result in disconnection from the Cooperative's system. The Cooperative will be under no obligation to reconnect the Member until the Member's generation facility either complies with the requirements in this Option, or is permanently disconnected from any parallel operation with Cooperative's system.

Technical Requirements For Parallel Operation of Member-Owned Generation

B - Generation Over 25 KW

1. General

1.1 These requirements shall be applicable to assure system safety and reliability of interconnected operations. The adequacy of safety and system protection of facilities for the interconnection with qualifying producers will be determined by the Cooperative but only insofar as necessary for such facilities to be determined compatible with the respective connecting system.

1.2 These guidelines are intended to cover all parallel operated generation including fossil fuel, photovoltaic, methane, wind generation and fuel cells. Isolated, but not limited to, generation systems that depend on a signal from the interconnected Cooperative line for synchronization may not require the extensive protective scheme(s) outlined in this guideline. This assumes the interconnection will promptly disconnect upon the loss of such signal. All other operating schemes must follow these guidelines. The Cooperative will be the sole judge as to the suitability of such parallel operations.

1.3 Should the parallel operation of the Member's generation facility cause interference or adversely affect voltage, frequency, harmonic content or power factor in the utility's system or other Members' service, the utility may prevent connection or require disconnection of parallel operation.

1.4 All protection, safety, and interconnecting equipment installed by producers must meet standards of prudent utility practices and be capable of continuous parallel operation with the Cooperative's system. This plan must be approved by a registered professional engineer.

1.5 THE MEMBER MUST OBTAIN FINAL APPROVAL FROM THE COOPERATIVE FOR ALL INTERCONNECTION FACILITIES AND INTERCONNECTED EQUIPMENT PRIOR TO ENERGIZATION OF THE PROJECT.

1.6 Qualifying producers will be required to provide proof of insurance coverage including liability coverage of a minimum of $1,000,000 per occurrence or greater and property loss insurance of $1,000,000. Higher amounts of coverage may be required at the discretion of the Cooperative.

1.7 The Cooperative will not be responsible for loss of equipment or revenue due to loss of service or system protection failure.

2. Safety

2.1 In order to provide safety for the connecting electric system's employees performing “emergency" repairs or routine maintenance to its lines, the Member must provide equipment for disconnecting and isolating the production facility during electric system interruption. Such equipment must be capable of preventing the production facility from energizing the system's lines during such interruptions and must include a device (or devices) which the electric system's employees can operate and lock so as to isolate the production facility and all means of backfeed into the connecting electric system.

3. System Protection

3.1 The Member is fully responsible for protecting his/her equipment in such a manner that faults or other disturbances on the Cooperative's system do not cause damage to it. The Member is also responsible for the design, installation, operation, and maintenance of his/her facility according to sound engineering practices so that his/her equipment does not reduce the quality of service to other Cooperative Members.

3.2 The design, testing, and maintenance of the necessary Member-owned protective equipment exclusive of that associated with the interface breaker connecting him/her to the Cooperative shall be totally the Member's responsibility.

3.3 A registered professional engineer shall make the selection and design of the interface breaker, and the associated protective relays shall be approved by the Cooperative prior to connection to the utility system. These relays and associated interface breaker must operate under any of the following conditions:

3.3.1 Faults on the Cooperative line that parallels with the Member generation.

3.3.2 Faults on the Member's system.

3.3.3 Non-fault opening to the Cooperative's source breaker(s), fuses, or switches supplying the line that parallels with the Member generation.

3.3.4 Reverse power flow between the Cooperative system and the Member generation which would cause damage to the Member's generation or equipment and Members connected to the Cooperative's system.

3.4 Proper operation of the interface breaker and associated protective relays for these four mentioned occurrences is extremely important in order to ensure personnel safety and that no damage occurs to equipment owned by other Members connected to the Cooperative and interconnected systems.

3.5 Annual maintenance and testing of the interface breaker and associated protective relays will be required in order to ensure their proper operation. This work should be performed by a reputable testing firm that will submit results to DEC for approval.

3.6 Appendix B (Fig. B-1 and B-2) provides detailed specifications covering the protective devices required for use with the sample one line diagrams illustrated in Appendix A.

3.7 The following protection and control requirements supplement the detailed specifications in Appendix B.

3.7.1 Fault Protection

(1) Adequate protection facilities and coordination shall be provided by the Member to protect the line(s) connecting the production facility to the electric system from faults originating from the production facility. This includes primary fault disconnecting switch gear and secondary relaying and control circuitry capable of isolating the production facility from the Cooperative's electric distribution system.

(2) It shall be the responsibility of the Member to provide adequate protection of its production facility from fault currents originating in the electric system.

3.7.2 Over Voltage and Under Voltage

(1) It shall be the responsibility of the Member to provide adequate protection or safeguards to prevent damage to the connecting electric system or the production facility caused by over voltage originating from the operation of the production facility and from inadvertent over voltages originating on the connecting electric system.

(2) It shall be the responsibility of the Member to provide facilities adequate to prevent the production facility from being damaged by under voltage conditions on the connecting electric system.

3.7.3 Synchronization and Isolation

(1) The Member shall provide facilities for the proper synchronization of its production facility with the connecting electric system such that synchronism is accomplished without causing undesirable currents, surges, or voltage dips on the connecting electric system.

(2) The Member shall provide means for disconnecting the production facility from the connecting electric system for system line interruptions and for the

proper resynchronization of the production facility following such interruptions.

3.7.4 Grounding

(1) The facilities (generator, connecting transformer, etc.) that connect to the electric system must be grounded in such a way that coordination is maintained with the relay protection system in use by the connecting electric system and prevents the connecting facility from being subjected to harmful voltages during fault conditions. Adequate neutral (ground) relays shall be installed to prevent ground fault transient damage or neutral induced voltage damage, and or unsafe conditions.

3.7.5 Harmonics

(1) Adequate design precautions must be taken by the Member to prevent excessive and harmful harmonic voltages or currents caused by the production facility from occurring on the connecting electric system.

(2) The production facility must be designed to operate with normal harmonic voltages and currents that originate from the connecting electric system.

3.7.6 Power Factor

(1) The operation of the production facility shall not produce excessive reactive power during off-peak conditions nor consume excessive reactive power during on-peak conditions. Power factor payments may be required to off-set the effect of excessive reactive power requirements.

3.7.7 Voltage Regulation

(1) The Member shall provide necessary voltage regulation equipment to prevent the production facility from causing excessive voltage variation on the connecting electric system. The voltage variation caused by the production facility must be within ranges capable of being handled by the voltage regulation facilities used by the connecting electric system.

3.7.8 Voltage Flicker

(1) The voltage produced by the production facility must be balanced if it is a three-phase installation. The wave-form must be sinusoidal and compatible with the operation of the connecting electric system.

(2) The Member will be responsible for protecting its production facility from the inadvertent phase unbalance in the connecting electric system's voltage.

4. System Protection Requirements

4.1 Qualifying producers will be required to provide and maintain suitable apparatus to prevent operation of their production facilities from causing unusual fluctuations or disturbances on the Cooperative's system.

4.2 Qualifying producers will cooperate with the Cooperative in developing mutually acceptable operating procedures for delivery of the output from the qualifying producer's facilities.

4.3 Qualifying producers will be responsible for providing and maintaining, during the term of the agreement, all equipment deemed necessary for the protection of their own property and maintain operations in a manner at least equal to current operating and maintenance practices and standards in the electrical industry. This provision shall not be construed as to prevent the Member from retiring any existing capacity.

4.4 The Member will be responsible for operating its production facility in a manner that will not cause undesirable or harmful effects to the connecting electric system or its other Members.

4.5 The completed installation must meet all local, state and national codes and regulations and is subject to inspection by proper enforcement authorities before commencement of operation.

4.6 THE MEMBER WILL NOT BEGIN INITIAL OPERATION OF THE PRODUCTION FACILITY UNTIL IT HAS RECEIVED WRITTEN APPROVAL FROM THE COOPERATIVE.

4.7 The Member shall supply the Cooperative with technical specifications, detail drawings, and site plans relating to the production facilities and related interconnection, operation, and protective equipment for review by the Cooperative.

4.8 The Cooperative shall have the right at any time to inspect and test the operation of any control and protective equipment owned and maintained by the Member and/or verify the Member's test data.

4.9 The Member shall advise the Cooperative prior to making any revisions to the Member's generation facility, the control system or the interface between the two power systems after the installation. Any such revision must be acceptable to the Cooperative.

4.10 Switching of the interface breaker (see breaker "X", Appendix A, Figs. A-1 and A-2) shall be under the administrative control of the Cooperative. The

Cooperative reserves the right to open (or request the opening of) the interface breaker without prior notice to the Member. The three following reasons are examples of why the Cooperative might exercise this right:

a. System emergency.

b. Cooperative's inspection of Member's interface station equipment reveals a potentially unsafe condition.

c. The Member's generating equipment interferes with other Members or with the safe operation of the Cooperative system.

4.11 The Cooperative also reserves the right to open (or request the opening of) the interface breaker with reasonable prior notice to the Member if a planned outage is scheduled on the Cooperative's supply feeder.

4.12 The Member shall provide the Cooperative an annual operations procedure report. This report shall include a test of all changes to the facility during the year and the purpose for the change. The report shall include a detailed description of any changes proposed in equipment or method of operation for the preceding twelve months and those anticipated for the next twelve months. The report shall also provide a list of each outage of the generation system and its cause. Further details may be requested by the Cooperative.

5. Other Technical Requirements

5.1 Interface Transformer Connections

Cooperative reserves the right to specify the types of transformer connections (e.g., delta-delta, delta-wye, wye-wye) that will be employed for all multi-phase interface transformers. This is necessary in order to ensure that such transformers will function in an optimum fashion with the Cooperative system. In the case of wye-delta connected transformers, the neutrals of any wye windings connected to the DEC system will be ungrounded unless unusual technical considerations dictate otherwise. The Member shall supply one copy of all transformer data and one copy of all certified test data.

5.2 Fuse Protection of High Voltage Side of Interface Transformer

The Member should employ a negative phase sequence over voltage relay as illustrated in Fig. B-2 when fuses provide high voltage protection for the interface transformer. This negative sequence relay should incorporate some fixed time delay so it will not operate for faults on the Cooperative system. Such faults usually result in temporarily unbalancing the voltages detected by the Member.

In such cases where such an arrangement exists, the Member should be made aware that his/her generator will be exposed to negative phase sequence voltages (and resultant negative phase sequence currents) if one of these high voltage fuses should open.

5.3 Reactive Requirements

Induction generators, such as indicated in Appendix A, Fig. A-4, contain no field for excitation purposes. Such devices draw reactive power (vars) from the utility system to satisfy their excitation needs. In order to generate watts, these machines (which are actually induction motors) are rotated at faster than synchronous speeds by their associated prime movers. The watt output increases as the margin above synchronous speed increases. Also, the amount of vars drawn from the utility increases as the generator watt output increases.

A three-phase synchronous inverter such as depicted in Appendix A, Fig. A-3 also draws a relatively large component of reactive power (vars) from the utility system. Power factor adjustment charges may be billed accordingly.

5.4 AC-DC-AC Links

The use of synchronous inverters and full wave rectifiers to form an AC-DC-AC link is a new concept to most utilities. This section summarizes some of the features that are unique to such a scheme (refer to Appendix A, Fig. A-3):

(1) BATTERY - The Member may elect to connect a battery to the DC bus in order to smooth the voltage ripple effect created by the pulses resulting from the operation of the full wave rectifier.

(2) HARMONICS - Because of harmonics that can be generated by the synchronous inverter, the Cooperative will allow no additional Members to connect to the secondary side of the interface transformer.

(3) Single phase Members with generation may be directly connected to a low voltage system which supplies other Members unless the size of the Member generation or any other constraint dictates the use of an interface (isolating) transformer. Installation approval of facilities and connection to the Cooperative must be approved by the Cooperative.

(4) REACTIVE POWER - As mentioned previously under the "REACTIVE REQUIREMENTS" heading, a relatively large quantity of reactive power (vars) can flow into a synchronous inverter from the utility during normal load conditions.

(5) MEMBER FAULTS - The utility will not be affected by faults internal to the Member's generator(s), rectifier, DC bus, or inverter, since the inverter blocks all current flow from the utility system to the Member's system.

(6) SYNCHRONIZING - Because of the DC portion of the AC-DC-AC link, no synchronizing is required when the generator is paralleled with the utility.

6. Miscellaneous

The following miscellaneous comments concerning the parallel operation of Member-owned generation are of general interest:

6.1 The Member should maintain a battery (48V or above) and charger for operation of his breaker and relays. In lieu of a battery, a properly designed capacitor tripping scheme may be employed if approved by the Cooperative.

6.2 The costs associated with any changes or new equipment required on the utility system as a result of increased fault current levels or special operating conditions produced by the Member's generator(s) will be borne by the Member.

6.3 All Member generators larger than 10 KVA must be three phase generators connected to three phase circuits.

6.4 Following the tripping of the Member interface breaker, a closure should never take place unless the Cooperative source is in normal operating condition and the Member side of the breaker is de-energized.

6.5 Distribution system loads are routinely switched from one feeder to another or from one supply station to another. Since the associated record keeping is sometimes difficult, maintaining proper utility protection for use with paralleled Member-owned generation is not an easy task. The Member should be aware that numerous switching operations (both three phase and single phase) routinely occur during the daily operation of a distribution system normally with prior notice.

APPENDIX A
TYPICAL BASIC ONE LINE DIAGRAMS

Fig. A-1, A-2, A-3, and A-4 in this Appendix illustrates in basic one-line fashion different possible configurations for the interfacing of paralleled Member generation with the Cooperative system. Since the different variations are infinite, these diagrams represent only four possibilities. However, these four variations would be typical of many such paralleled arrangements.

Fig. A-1 is typical of a large capacity synchronous generator that has an interface breaker "X" located on the high voltage side of the interface transformer. Such a generator could be paralleled with a Cooperative transmission (138kV or 69kV), or distribution (25kV or 12kV) facility.

Fig. A-2 illustrates a typical small three phase synchronous generator that has fuses located on the high voltage side of the interface transformer. In this case, the interface breaker "X" is located on the low voltage side of the interface transformer. Normally, such an installation would be paralleled only with a Cooperative distribution (25kV or 12kV) facility.

Fig. A-3 depicts a typical small three phase synchronous generator which could be paralleled with the Cooperative through a full wave rectifier synchronous inverter (AC-DC-AC) link. Such an arrangement is typical of relatively small wind turbine-generators. This type of arrangement is discussed in further detail in the main body of this document under the heading "AC-DC-AC LINKS". Such a system could be paralleled only with a Cooperative distribution (25kV or 12kV) facility.

Fig. A-4 represents the least complex paralleling arrangement possible - a single phase 120V induction generator which the Member can parallel by merely connecting into the secondary system as indicated. Since the induction generator contains no field, it must draw vars from the Cooperative system for excitation purposes. These types of generators need not be synchronized to the system. This concept is discussed in more detail in the main body of this document under the heading "REACTIVE REQUIREMENTS".

APPENDIX B
DETAILED PROTECTIVE RELAY SPECIFICATIONS

This Appendix outlines in detail the protective relaying that will be required by the Cooperative for installations such as those depicted in Appendix A.

(Figs. A-1, A-2, A-3, and A-4). The relaying used to protect the Member's generator(s), feeders, buses, etc., will not be addressed here - the Member will assume full responsibility for this area as mentioned in the main body of this guideline. The four sub-headings below refer to the appropriate one-line diagrams that were discussed in Appendix A. Figures B-1 and B-2 attached to this Appendix indicate only the portions of the system that are of interest in this discussion of the detailed protective relay specifications.

The numbers in parentheses appearing on Figs. B-1 and B-2 represent the appropriate ANSI standard designations for each relay function.

Fig. A-1 - (Refer also to Fig. B-1) "OC" (50/51) represents time delay phase over-current relays with instantaneous units. These three relays must have settings that will ensure their coordination under similar relays connected at the Cooperative source substation for faults in the area of the interface transformer.

"OC-G" (50/5lN) represents a time delay ground over-current relay with an instantaneous unit. This relay must have a setting that will ensure its coordination under a similar relay connected at the Cooperative source substation for faults in the area of the interface transformer.

"OV-G" (59G) represents a voltage relay which incorporates time delay. Such a relay will be required if the high voltage winding of the interface transformer is connected either delta or wve with the neutral ungrounded - the use of either of these two types of high side windings will be normal practice. The zero phase sequence component of voltage created by faults involving ground on the paralleled Cooperative transmission or distribution line will operate this relay, resulting in disconnection of the Member's load and generation by tripping breaker "X".

"OCD" (67) represents time delay phase directional over-current relays. These will be connected to "look out" into the Cooperative system. They will detect phase faults and remove the Member from the system by tripping breaker "Y".

"PD" (32) represents a power directional relay connected to "look out" into the Cooperative system. This relay will have a setting that will allow the Member’s generator(s) to supply reasonable amounts of power into the Cooperative system, depending upon the generator size, distribution conductor capacity, etc. However, the relay will operate to trip breaker "Y" if the power flow from the Member to the Cooperative exceeds a given level.

This may happen when the associated Cooperative source breaker opens, causing the Member's generator(s) to try to supply all the other Members connected to the Cooperative line in addition to supplying all their own load. Some time delay will have to be incorporated into this relay in order to prevent it from operating during synchronizing swings.

"UF" (81) represents an under frequency relay. It will be set to trip breaker "Y" if the frequency drops to 59.0 HZ or below. Such a frequency decay may occur when the associated Cooperative source breaker opens, causing the Member's generator(s) to try to supply all the other Members connected to the Cooperative line in addition to supplying all their own load.

"OF" (81) represents an over frequency relay. It will be set to trip breaker "Y" if the frequency rises to 61.0 HZ or above. This frequency rise may result if the Member's generation should become isolated with a small portion of the system, and the total resulting load is less than the Member's generating capability.

" UV " (27) represents an under voltage relay. It must have an associated fixed time delay of at least 2 sec. to allow for local motor starting and for faults out on the Cooperative system that are not cleared rapidly. The relay will trip breaker "Y" if the Member voltage drops below 0.85 times normal for the required fixed time delay.

"OV" (59) represents an over voltage relay. It will trip breaker "Y" instantaneously if the Member voltage exceeds 1.15 times normal.

Either the under voltage or over voltage relay may isolate the Member generation from Cooperative in cases where the Cooperative source breaker may open. Whether the under voltage or over voltage relay operates would depend upon the resulting generation - load balance.

Fig. A-2 (Refer also to Fig. B-2) - All protective relays indicated on this drawing with the exception of NPS would serve functions identical to their counterparts illustrated on Fig. B-1 which was just discussed. The need for the NPS relay in this type of configuration was discussed in the main body of this document under the heading "FUSE PROTECTION OF HIGH VOLTAGE SIDE OF INTERFACE TRANSFORMER". Note that all the relays depicted on Fig. B-2 will trip breaker "X" (the interface breaker).

Fig. A-3 - The Cooperative would require no Member protective relays per se with such an arrangement. From a safety standpoint, it would be impossible to feed from the synchronous inverter into the utility network when the paralleled utility line is de-energized. First of all, today's inverters obtain their triggering signal from the utility source. Once this is lost, no electronic switching can take place, and the Member generation is effectively isolated.

Second, additional protection is provided by Member-owned contactors whose coils are supplied from AC. Their associated contacts are connected on both sides of the inverter. Therefore, if the utility source is lost, both sets of these contactors open to provide additional

isolation of the Member-owned generation from the utility. Third, fuses should disconnect the Member-owned generation from the utility for faults in their electronic switching equipment.

Fig. A-4 - This type of small single phase installation requires no protection as far as the Cooperative is concerned. Because the generator draws vars from the utility for excitation purposes, it can no longer produce watts once the utility supply is lost, since this causes a rapid decay of its terminal voltage.

A large three phase induction generator could possibly continue to produce watts even when the utility supply feeder is lost. This could happen only if adequate nearby shunt capacitors were present to supply the required excitation, and the machine were large enough to carry the resultant load imposed upon it. In cases such as this, the Cooperative would require over and under frequency plus over and under voltage protection as outlined in Figs. B-1 and B-2.